Herd specific economic values on breeding goal traits in dairy cattle

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Tiivistelmä – Referent - Abstract

Lypsykarjajalostus on ollut taloudellisten arvojen ohjaamaa jo 1930-luvulta lähtien. Perinteisesti suurimmat taloudelliset arvot ovat olleet niillä jalostettavilla ominaisuuksilla, jotka joko tuovat tuottajalle lisää voittoja tai vähentävät kustannuksia. Tämän takia maitotuotoksen taloudellinen arvo on ollut suurin. Suomessa oli vuonna 2018 6250 lypsykarjatilaa, jotka ovat kaikki keskenään erilaisia. Niillä on paitsi erilainen karja-aines, mutta myös tuotantoympäristö, hinnat ja kustannukset eroavat toisistaan. Karjojen välillä on eroja myös jalostustavoitteissa, sillä niihin vaikuttavat muun muassa tuottajan koulutus, mieltymykset sekä karjan lähtötilanne. Suomi on mukana NAVissa, ja Suomen jalostusohjelmassa on käytössä Pohjoismainen kokonaisjalostusarvo NTM. Suomessa tarvetta useammalle kokonaisjalostusarvolle ei ole tutkittu.

Tämän tutkimuksen tavoitteena oli selvittää tilakohtaisten taloudellisten arvojen kautta, onko tilakohtaiselle kokonaisjalostusarvolle tarvetta. Tavoitteena oli myös tutkia, eroavatko ominaisuuksien taloudelliset arvot tavanomaisen- ja luomutuotannon välillä. Tutkimus toteutettiin seitsemän karjan tiedoilla. Kaikki karjat olivat keskenään erilaisia ja kaksi niistä oli luomutiloja. Taloudelliset arvot laskettiin SimHerd-mallinnusohjelmalla, joka simuloi karjan eläimiä viikoittaisissa sykleissä ottaen huomioon kaikki eläimen elämän tapahtumat, sekä laskee sairastumisen todennäköisyyksiä karjan lähtötason tietojen perusteella. Taloudelliset arvot laskettiin energiakorjatulle maitotuotokselle, lehmien tiinehtyvyydelle, hiehojen tiinehtyvyydelle, utaretulehdukselle, lehmien kuolleisuudelle, vasikkakuolleisuudelle, jalka- ja sorkkaterveydelle rehunkäyttökyvylle, elopainolle sekä muille poistoille.

Karjakohtaiset lähtötiedot sekä hinnat ja kustannukset olivat vuodelta 2018. Suomalainen maidontuotanto on hyvin riippuvainen maataloustuista, mutta niiden haasteellisen laskutavan vuoksi ainoastaan maidon suorat tuet otettiin huomioon tässä tutkimuksessa. Ominaisuuksien väliset yhteydet poistettiin mallinnusohjelmassa ennen simulaatioita. Kaikkien karjojen lehmäluku asetettiin 1000 lehmään, jotta simulaatioissa vältyttäisiin sattuman vaikutukselta. Jokainen skenaario simuloitiin kolme kertaa: ensin karjan lähtötiedoilla ja sitten tutkittavan ominaisuuden korotetulla ja alennetulla parametrillä.

Tulosten mukaan korkein taloudellinen arvo oli energiakorjatulla maitotuotoksella kaikilla tutkimuksen tiloilla. Suuria taloudellisia arvoja saivat myös elopaino, lehmien tiinehtyvyys ja lehmien kuolleisuus. Taloudelliset arvot erosivat toisistaan eri tilojen ja tuotantosuuntien välillä, mutta olivat keskenään samansuuruisia. Lehmien kestävyyteen vaikuttavat ominaisuudet saivat yhteenlaskettuna suurimman prosenttiosuuden kaikkien tutkittujen ominaisuuksien taloudellisten arvojen summasta. Kestävämmät lehmät ovat paitsi taloudellisesti kannattavampia, myös ympäristön kannalta toivottuja. Kun tuloksia vertailtiin tilojen välillä, niistä ei ollut huomattavissa tarvetta tilakohtaiselle kokonaisjalostusarvolle. Luomutiloille tarkoitettua omaa kokonaisjalostusarvoa tulisi tämän tutkimuksen tulosten perusteella tutkia lisää.

Avainsanat — Nyckelord — Keywords
kotieläinjalostus, taloudellinen arvo, SimHerd

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Ohjaajat Jarmo Juga, Morten Kargo ja Søren Østergaard

ABSTRACT

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Tiivistelmä – Referent - Abstract

Dairy cattle breeding has been driven by economics since the 1930s. For a longer period, the cost-effectiveness of dairy farming has been poor, and the farmers have been forced to look for all possible ways to improve economics, through either reducing costs or increasing profit. Finland had in 2018 6250 dairy farms, which all differ from each other by size, economics and production environment. Finland participates to Nordic Cattle Genetic Evaluation (NAV) and uses Nordic Total Merit (NTM) as a joint total merit index for Finland, Denmark and Sweden. It has not been published, whether Finnish dairy farms would need more farm specific total merit indices. Breeding goal preferences do differ not only between farms but also between production types, since organic farmers tend to put more emphasis on production, compared to conventional.

The aim of this study was to study whether economic values on breeding goal traits differ between farms and production types. Herd specific economic values were counted for ten breeding goal traits. The study was fulfilled with seven dairy herds, who differed from each other by herd size and production environment. Two of the herds were organic. The calculation of economic values was based on a bioeconomic model SimHerd. It is a stochastic simulation model, which simulates the herd in weekly steps, taking all events in a cow's life into account. Traits analyzed in this study were chosen according to hypotheses of their economic values. Traits analyzed were ECM yield, mastitis, conception rate of cows, conception rate of heifers, cow mortality, calf mortality, claw and leg diseases, feed efficiency, body weight and other culling.

Prices and variable costs as well as the phenotypic data of the farms was collected from the year 2018. Finnish milk production is highly dependent of subsidies, but due to their complexity, only direct subsidies for milk were considered in this study. Relations between traits were cut off from the model before simulation. The maximum number of cows for each farm was set to 1000 to improve the reliability of the simulations. Each trait was simulated three times: with the phenotypic data and then twice with changing the parameter.

According to the results, the relative economic value of ECM yield was the highest for all farms. The highest economic values differ between farms, but on average the next highest economic values were for body weight, conception rate of cows and cow mortality. These economic values were in the same range for both conventional and organic farms. When relative economic values are presented as percentages of the sum of standardized economic values, traits affecting longevity cover together the greatest percentage. With improved longevity the cows have more productive years, which means greater lifetime milk yield, less replacement cots and smaller environmental impact. When results were compared between farms, they showed no need for farm specific TMI. A different TMI for organic production would need a further research.

Avainsanat — Nyckelord — Keywords

economic values, SimHerd, herd specific

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Supervisors Jarmo Juga, Morten Kargo and Søren Østergaard.

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1. Introduction

Animal breeding in dairy farming is often considered as a work, a hobby or a passion, depending on the breeder themself. Although animal breeding can be divisive, its importance is recognized all over the world. In the best case animal breeding can improve food security, animal health and welfare, production profitability and safety of the farmer. Animal breeding also has an impact on global food production and therefore effects on environment and global economics. The commitment to responsible breeding from Code-EFABAR points out the role of farm animal breeding: "Farm animal breeding is now increasingly more balanced and sustainable – improved science, larger breeding populations and modern computing power are delivering better balanced breeding programs which address the key issues of food safety and public health, product quality, genetic diversity, efficiency, environmental impact, animal health, and animal welfare." (Code-EFABAR 2014).

Dairy cattle breeding has been driven by economics since the 1930s (Miglior et al. 2017). Farming is business, of which cost-effectiveness has been poor for a longer period (Luke 2020). That has forced the farmers to look for all possible ways either to increase profit or reduce costs. One of the possibilities is animal breeding. Finnish dairy sector has gone through big structural changes. Simultaneously the number of dairy farms has decreased rapidly, the decreasing of number of dairy cows has been more moderate in the last ten years (Nokka 2019). Many small dairy farms have quit production and the farms who continue milk production have invested in greater number of animals per farm. In 2018 dairy farms had on average 45,6 cows, which was 1,8 cows more than a year before (Nokka 2019). Organic farms had on average 60,3 cows (Nokka 2019). Finnish milk production is highly dependent on agricultural subsidies from the European Union and Finnish government (Hietala et al. 2014). Finnish milk production is fragile to changes in agricultural politics in the EU, which have occurred in the dairy sector for a longer time (Bouamra-Mechemache et al. 2008). The biggest changes in Finnish dairy sector have been the removal of quotas in 2015 (Puhto 2015) and the Russian import ban for European products in 2014 (European commission 2014).

Economic profitability requires greater revenues compared to costs (Wolfova et al. 2007). In dairy production revenues come from sold products and subsidies, and costs consist of feeding, labor and other expences needed for maintaining the animals. Dairy cattle breeding used to be focused on production traits (Weiske et al. 2006) but functional traits, such as health and fertility have been brought into total merit indexes in the early 2000's (Carlen et al. 2015). During the history of total merit index selection milk yield or its components have had the highest economic value (Miglior et al. 2017). Wolfova et al (2007) points out that the possible changes in milk pricing due to politics should be considered when defining a breeding goal.

For a trait to be considered as a breeding goal, it needs to have an impact on economics, heritability and variation of the trait need to be great enough and the trait needs to be clearly defined as well as easy to measure (Miglior et al. 2017). Breeding goals can be divided into two groups. They either bring the farmer more revenues or reduce costs (Bo 2009). These are also known as productive and functional traits. Improvement of functional traits, such as health, fertility and feed efficiency, reduce expenses from veterinary costs, disposed milk and with smaller amount of feed needed. Breeding goal traits have changed over time due to low milk prices, higher costs of medicine and labor and consumers' demands. There are differences between farms, whether they implement breeding or management strategies that bring in more money or concentrate on reducing costs (Hogeveen et al. 2010).

Finland had in 2018 6 250 dairy farms (Luke 2019). Farms differ from each other not only by size, economics or production environment, but also by farmers' preferences with management, production and animal breeding. It has not been published, whether Finnish dairy farms differ from each other that much that there would be a need for more farm specific total merit indices. The base of total merit index is in economic values and therefore the aim of this study was to calculate farm specific economic values and compare them between farms with different number of animals and production environment.

2. Literature review

2.1. Total merit index selection

Finland participates to NAV (Nordic Cattle Genetic Evaluation). NAV estimates jointly the breeding values (EBV) for three Nordic dairy cattle populations in Denmark, Finland and Sweden. The EBVs of the most economically important traits are aggregated to a Nordic Total Merit (NTM) assuming the same breeding goal in all three countries. The aim of NTM is healthy, fertile, well-productive dairy cow with a long productive life and functional conformation (NAV 2020). NTM is used in selection program of bulls as well as for dam selection on farm level. NTM is created to narrow the differences between production environments in order to create a uniform selection index that can be used nationwide. In the NTM different traits are weighted according to their importance. Production covers 30 percent, health and fertility 53 percent and conformation 17 percent of the total index (NAV 2020). During the last years breeding has focused more on functional and health traits (Miglior et al. 2017) which has been a benefit for the whole dairy sector.

2.2 Herd specific breeding goal traits

Farmers' preferences on breeding goals differ from each other (Martin-Collado et al. 2015, Slagboom et al. 2016). According to Slagboom et al. (2016) research Danish farmers' preferred breeding goals could be divided into clusters: health and fertility, production and udder health, survival, fertility and production. Paakala et al. (2018) found similar results among Finnish farmers, whose preferences were grouped into four groups: production herds, fertility herds, all-rounder herds and conformation herds. Farms were grouped according to the trait they emphasized the most, detriment of other traits. It has brought into discussion, that if farmers' preferences on breeding goals strongly differ from each other, there might be a need for several total merit indexes (Nielsen & Amer 2007). This has been put to practice in Australia, where farmers can choose from three different TMIs, Balanced performance index, Health weight index and Type weighted index the one that fits their breeding goals the best (Byrne et al. 2016).

Animal breeding decision making is often found complex by farmers. According to Martin-Collado et al. (2018) complexity of breeding decision making consists of many different parts. Farmer's decision-making ability is affected by the level of education and practical experience in breeding and dairy farming. The herd size and dynamics make the decision-making more complex: number of cows in the herd or sires available to choose from as well as the information available. Martin-Collado et al (2018) presented in their study that in this era of genomic data together with all measured data from milk recordings as well as different data for example from milking robots can cause information overload and make it even more complex to decide, which animals or traits to breed. Martin-Collado et al. (2018) also present existing trade-offs between production and functional traits and animals with unique features as principles that explain the complexity of animal breeding decision making. Perfect animals, that would have all the features desired by the farmer without the unwanted features, do not exist. The farmer needs to decide, which of the traits are most important and not to forget correlations between traits. With unique features, the authors mean genetic disorders, such as polled animals or carrier or non-carriers of disadvantageous gene, that might affect the decision whether to use the cow as a dam for the next generation.

One of the most important aspects in decision making is on which data the farmer’s decisions are based on. Multiple sources of information often exist describing the animals’ merit, such as estimated breeding values of several traits, selection index values calculated by the breeding association, pedigree information, the animal’s own performance data as well as the appearance and functionality of the animal. The farmer needs to decide which of the data to use and what are their motives to use that exact data.

2.3 Specialties for organic production

Organic production has more strict rules for production than conventional production. Finland has about 150 organic dairy farms and they produce 3 to 4 percent of Finnish milk. According to ProLuomu (2018), “Organic production combines the best production actions for environment and animal welfare, taking also consumers’ demands into account.” In Finnish organic dairy production farms are committed to regulations of organic production. These differ from conventional production mainly with feed and housing. Organic dairy cows are fed only organic feed (ProLuomu 2018). Feeds that contain genetically modified organisms (GMO) are forbidden in both production types, but in organic production also artificial fertilizers and pesticides are forbidden. Over half of the feed of cows needs to come from the farm or other organic farms nearby. In organic milk production concentrate percentage must not exceed 40 percent. Calves in organic production are not fed with milk powder, but milk until the age of three months, whereas in Finnish conventional farms the preferred age for transition from milk to roughage is two months. If the animal needs antibiotics, the withdrawal time of milk and meat is double compared to conventional production. There is more regulation of housing for organic dairy farms than conventional. Cows have more space per animal and the floor can be only partially grate floor and all animals need to have a possibility to lay down at the same time. Although organic dairy farms are mainly loose stalls, all organic cows and calves over 3 months of age need to have access to pasture daily between June and September. In organic tie stall farm the cows need to have access to enclosure outdoors twice a week also outside pasture season (ProLuomu 2018).

Little discussion or research has been published on different breeding goals for organic production, since the research has mainly focused on nutrition, health and welfare (Rozzi et al. 2007). At this moment, organic farmers use the same production-weighed total merit to select their animals as conventional farmers.

Rozzi et al. (2007) pointed out the complexity of organic breeding program, since organic farms are mainly smaller than conventional and have a big variation between farms. In Finland organic dairy farms are on average bigger than conventional (Nokka 2019). The need of a different breeding program for organic farms can be explained by different disease treatments and different feeding strategy, which points out the need of better feed efficiency and health traits. Many organic dairy farmers prefer conservation of genetic resources by growing local or traditional breeds (Rozzi et al. 2007). Selecting traditional breeds or crosses often leads to better health, fertility and longevity (Claesen et al. 2017).

Slagboom et al. (2016) suggested that farmers' breeding goals do differ between farms. Farmers tend to put more emphasis on the traits they have more problems in their herd. Farmers prefer different traits in their herd, depending on farmer's age and sex, but also production type (Slagboom et al. 2016). Slagboom et al. (2016) found that both production strategies valued health and fertility traits, but organic dairy farmers put more emphasis on production than conventional dairy farmers (Slagboom et al. 2016).

3. Research objectives

The aim of this study was to determinate herd specific economic values on different breeding goal traits. The second goal was to see if the economic values differ between production types, mainly organic or conventional.

The hypothesis of the study was that the economical values do differ between different types of farms. Also economic values in organic milk production are presumed to be different than in conventional milk production. It was assumed that the economical values in health traits are greater in organic than in conventional production.

4. Materials and methods

The estimation of economic values composed of different steps: 1) collecting data from the farms, 2) entering the data into SimHerd, 3) simulations with SimHerd and 4) calculating and analyzing the results with Microsoft Excel. Each of the seven farms who entered this study differed from each other with management, prices and costs and production strategies. Each farm has also their specific economic efficiency, which includes revenues and costs, like presented by Wolfova et al. (2007). Wolfova et al. (2007) presented economic efficiency with an equation:

$$profit = rev'NDE^{[rev]} - cost'NDE^{[cost]}$$

where rev' and cost' are row vectors of revenues and costs. $NDE^{[rev]}$ and $NDE^{[cost]}$ are the column vectors of the number of discounted expressions connected with revenues and costs (Wolfova et al. 2007). All revenues and costs are calculated per animal on the farm (Wolfova et al. 2007). They include all occasions during one year of cow's life. Revenues on a dairy farm come from sold milk and heifers and culled cows. Depending on the farm's strategy they get revenues also from sold bull and cross-bred heifer calves or fattened bulls sold to slaughter. Costs in this study consist only from variable costs, feeding, labor, veterinary costs and artificial insemination. As well as revenues, costs are also farm specific and depend on management, feeding strategies and the size of the farm. In this study, only the change in gross margin after changing a parameter was observed. Economic differences between farms or farm level economics were not considered or focused on.

4.1 Model

The derivation of economic values was based on a bioeconomic model SimHerd. SimHerd is a dynamic stochastic simulation model for dairy herds and a tool for research and development (Soerensen et al. 1992). It simulates the herd in weekly steps, taking all events in a cow's life into account, with additional young stock. It characterizes animals individually by age, lactation number and stage, milk yield, body weight, pregnancy status and disease occurrence (Soerensen et al.2000, Nielsen et al. 2006). All discrete events and individual variation at cow level, such as conception, fetus death, sex of the calf, milk yield potential, involuntary culling, diseases and death are triggered stochastically (Oestergaard et al. 2000). The model simulates state changes and production of the herd by conditionally independent state changes of each cow and heifer, depending on herd level (Oestergaard et al. 2000).

The model controls the number of cows by probability of birth of a heifer calf and the rate of stillbirths and calf mortality in herd. The model assumes that all bull calves are sold at young age (Oestergaard et al. 2000). Heifer calves are used as replacements. The model assumes that surplus heifers are sold at the age of calving, but it can be changed so that heifers are never sold. A heifer is surplus if the number of cows in the herd is at its maximum and there are no cows selected for culling (Nielsen et al. 2006). Replacement heifer is purchased if the number of cows would reach the specified minimum (Nielsen et al. 2006). Culling strategy can be controlled in the model by herd size, low milk yield and maximum number of days open.

Milk production is modelled with lactation curve (Soerensen et al. 1992). Milk production is 25% lower for primiparous cows in the first 24 weeks compared to multiparous cows (Soerensen et al.1992). Net energy in the model calculated from available net energy by subtracting the needs of maintenance and pregnancy. Any extra net energy is transformed to gain (Soerensen et al.1992). Milk production can never be negative. Model assumes that cows are fed grass silage ad libitum and a constant rate of concentrate at three levels. Feed efficiency in the model is assumed to be 0,88, and similar for all primiparous cows. Older cows' feed efficiency is 1,00 and it differs because of different production and feed intake (Soerensen et al. 1992).

Estrous cycle of animals start when a heifer reaches a certain age. Estrous cycle differs among heifers is assumed to be 3 weeks and gestation length 40 weeks. Estrous cycle differs among animals due to a draw from a lognormal distribution. Pregnancy is controlled by conception rate, risk of fetal death and an estrous detection rate. Fetal death is triggered stochastically. (Soerensen et al.1992).

The model uses phenotypic data of each herd to calculate revenues and costs. Phenotypic data used in this research can be found in attached file 1.

4.2 Traits chosen for this study

Traits to analyze in this study were chosen according to hypotheses of their economic value and improving possibilities. Most common reasons for culling in Finland in 2018 were poor fertility

(22,8%), poor yield or breeding value (18,2%) and mastitis (11,0%) for first parity cows and mastitis (23,6%), poor fertility (16,5%) and poor yield or breeding value (8,3%) for older cows (Nokka 2019). Cost of feed is the biggest cost on Finnish dairy farms (Hietala et al. 2014). Reducing feeding costs can have a big impact on farm's gross margin. Feed efficiency is positively correlated with milk production (Wall et al. 2010). Improving feed efficiency also reduces greenhouse gas, especially methane emissions from dairy sector, when all emissions from feed production as well as from ruminants' digestion are considered (Hegarty et al. 2007).

Among those traits, also live body weight, cow mortality, other culling and calf mortality after birth were considered in this study.

Table 1. Traits, their definitions and the variable in SimHerd to cause the change in the trait

Trait	Definition	Parameter changed in SimHerd
ECM	Energy correlated milk yield per cow	Peak yield for 1st, 2nd and 3rd + parity cows
Mastitis	Mastitis case which requires milk disposal or antibiotic treatment	Base risk for a parity 3 cow to get mastitis. Serves as the intercept definition.
Conception rate cows	Conception rate of healthy cows	Conception rate cows
Conception rate heifers	Conception rate of heifers at insemination	Conception rate heifers
Cow mortality	Cows that die or get euthanized	Cow mortality
Calf mortality	Calf mortality after birth until the age of 180 days	Calf mortality
Claw and leg diseases	claw and leg problems: sole ulcer, white line, overgrown claws, etc.	Base risk for a parity 3 cow to get claw and leg problems
Feed efficiency	Efficiency of the feed for the lactating cows	Feed efficiency
Body weight	Mature body weight	Mature body weight
Other culling	Culling due to reasons other than low milk yield or failure to conceive. Accidents, cow's exterior or temperament: the cow leaves the herd instantly	Other culling

When simulating the herds for ECM yield, parameters of peak yield were changed. The parameters of persistency remained unchanged. The persistency for milk production was 13,6%, 30,6% and 36,5% drop from day 60 to 305 for 1st, 2nd and third parity cows, respectively.

The parameters changed in simulations of mastitis and claw and leg diseases were base risks for a parity 3 cow to get the disease. The odds ratios for parity 1 vs. 3 and parity 2 vs. 3 remained unchanged for all herds.

4.3 Farms

This research was carried out on seven (7) different dairy farms, located in different parts of Finland. Farms entered the study voluntarily. Characteristic to the farms included in the study was that the number of cows was above the average in Finland (45,6), barns for the cows were modern and the owners were eager to continue farming also in the future. The farms were labelled with alphabets A to G, to keep the study anonymous. All the farms had loose stall housing systems. Five of the seven farms had automatic milking system. On farms E and G heifers were naturally bred using a farm bull, otherwise all breeding was made with AI. Farms B, D and G grew their bull calves until slaughter. Farms A, C, E and F sold bull calves and cross-bred heifer calves at the age of 14 days. Farms E and G were organic.

The information considered in this research was from year 2018 for farms A, B, C, D, E and F. For farm G the year 2018 was poor due to other than genetic reasons. Simulations with the information of that year did not show realistic results. Therefore, for farm G the information considered in this research was from year 2019.

The economic values in this study were calculated for the whole herd and are not breed specific as usually.

Table 2. Farm information

FARM ID	farming type	number cows in cow years	production kg ECM / cow / year	Strategy of bull calves
A	conventional	71,4	10459	sold at 2 weeks
B	conventional	214,1	11939	Fattened on the farm
C	conventional	75,2	11399	Sold at 2 weeks
D	conventional	161,7	10212	Fattened on the farm
E	organic	72,5	11103	Sold at 2 weeks
F	conventional	51,9	11691	Sold at 2 weeks
G	organic	46,6	9346	Fattened on the farm

The raw data from farms was entered into SimHerd. Parameters were adjusted in order to make the calculations fit the actual situation: for example, parameters “Start breeding, first parity cows” and “heat observation rate” were adjusted to make calving interval fit the farm’s records. Heat observation rate was set to 90, in the cases where heifers were bred with a bull. Conception rate in these cases was set to 69, since there was no exact data available.

4.4 Prices and costs

Only variable costs were considered in this study. Finnish milk production is highly dependent on subsidies, but due to their complexity, only direct subsidies for milk were considered in this study. All prices used in this study can be found in table 3.

The price of milk varied between farms mainly due to different fat and protein percentages. It also varied between farms because of different subsidy levels in different parts of Finland. Farms A and C are located in AB area, B and D in C1 and E, F and G in area C2. The subsidy for milk production in 2018 for C1 area was 7,55 cents per liter and in C2 area 8,25 cents per liter. There is no subsidy per liter in area AB (Ruokavirasto 2020), where farms A and C are.

None of the farms had exact data on feed costs, due to lack of knowledge on price of roughage grown and ensiled on the farm. The prices of feed were estimated for organic and conventional farms in different parts of Finland, due to differences in growing seasons. According to a short oral inquiry among farmers the prices were set to 0,14 euros per kg of silage dry matter in southern Finland, 0,20 euros in northern Finland and 0,32 euros for organic production.

Price of a cull cow for conventional farming was set to 1,37e/kg live weight. For organic production the price of a cull cow was set to 2,05e/kg live weight. Price of disposing a dead cow aged over 6 months was 110,34 euros (Raatonetti 2013).

From the interviews of farmers, the price for a bull calf was set to 170 euros, for cross-bred bull calf 200 euros and for cross-bred heifer calf 87,25 euros. On the farms, that grew their bull calves until slaughter, the price of a bull calf was set to 450 euros. This price was calculated by the price of a two weeks old calf plus the gross margin profit the farmer gets from slaughter animal. The profit was approximated, since the farms had no calculations of their own. According to Heiska (2015) the profit per bull is about 521 euros in subsidy-area C. Heiska’s (2015) calculations include subsidies and therefore the profit per bull in this study was set to 450 euros and profit per cross-bred heifer to 350 euros without subsidies.

Price of a pregnant heifer for conventional farm was set to 1400 euros and for organic farms 1600 euros as estimated by the farmers. Prices per insemination varied because some farmers inseminated their cows themselves and others used a service provider. The prices include the cost of a dose and work and are calculated according to Faba's and Semex Finland's tables.

Table 3. Price variables used in the study

VARIABLE	A	B	C	D	E	F	G
ecm milk	0,37	0,43	0,37	0,44	0,58	0,46	0,58
feed	0,19	0,20	0,19	0,20	0,32	0,20	0,32
meat e/kg live weight	1,37	1,37	2,05	1,37	2,05	1,37	2,05
Dead cow disposal	110,34e	110,34e	110,34e	110,34	110,34	110,34	110,34
Milk powder e/kg	1,91 (7,30snt/l)	1,91	1,91	1,91	3,09	1,91	3,09
Bull calf	170e	450e	170e	450e	170e	170e	450e
Cross-bred bull calf	200e	450e	200e	450e	200e	200e	450e
Cross-bred heifer calf	87,25e	87,25e	87,25e	87,25e	87,25e	87,25e	350e
Breeding proven bull, dose included	51,95e	37,62e	51,95e	25,79e	51,95e	51,95e	38,57e
Breeding sexed proven bull, dose included	64,95e	47,62e	64,95e	38,79e	64,95e	64,95e	48,57e
Breeding beef bull, dose included	43,95e	15,62e	43,95e	17,79e	43,95e	43,95e	16,57e
Breeding sexed beef bull, dose included	61,95e	35,62e	61,95e	17,80e	64,91e	64,91e	36,57e

4.5 Double counting

As Kargo et al. (2014) present, there are relationships among traits that need to be taken into consideration when estimating economic values to avoid double counting. For example, the economic value of reduced milk production due to foul in the foot should not be included into the economic value of foul in the foot. They both are two different traits with economic values of their own and therefore the economic value of reduced milk production should not be included in health traits (Oestergaard et al. 2016). In this study we were looking at one trait at a time and therefore these relationships were cut before simulating. Relationships were cut in SimHerd by decreasing the effect to zero. These effects were effects for milk yield, risk of death, risk of culling, effect on reproduction, effect in body weight and effect in body weight gain. The possibility for double counting was considered for all traits, and relationships were cut for mastitis and for claw and feet diseases.

4.6 Simulation

The maximum number of cows for each farm was set to 1000 in order to get enough replicates. If a scenario is run with too small number of replicates, the change in parameters due to random error increases. In herds with a small number of cows, a single simulation alternative might show a great change in percentages as well as in economic values. The model was then run at basic level, with the phenotypic data of each farm entered in the model. After that, each scenario was run with changed parameter values in SimHerd and run again, while other parameters remained constant. The effect of a trait change was observed as a change in gross margin and gross margin per cow year, as well as the change in phenotypic values.

All situations were simulated three times: base situation with the current performance level as recorded on the farm and alternatives when increasing or decreasing the trait parameter with a defined change. The change in the parameters for this study were 10 units for traits mastitis, claw and leg problems and other culling and 5 units for feed efficiency. For yield the change was two kilograms of daily yield in the peak lactation for each lactating groups. For conception rate the change was 5 conception rate points and for body weight 50 kilograms. The change of cow mortality and calf mortality after birth was 5 units but was not set below zero in decreased scenario. Each scenario produced a report with changes in both economic and other parameters, such as herd dynamics and diseases due to a change in the single trait parameter. Although double counting was considered and prevented, some minor double counting effects were still present in the simulation.

A change in conception rate altered milk yield per cow year, number of productive years, lifetime production, calving interval, replacement rate and age at first calving. When the parameter for feed efficiency was changed, a change was also seen in feed intake per cow, gram methane per kg ECM, milk yield, lifetime production and somatic cell count. Changes in mature body weight altered feed intake, gram methane per kg ecm, somatic cell count, milk yield and lifetime production. When claw and leg problems were changed, milk yield, somatic cell count, feed intake, lifetime production and replacement rate changed A change in risk of involuntary culling altered milk yield, somatic cell count, feed intake, lifetime production and replacement rate. When the risk parameter for cow mortality was changed, lifetime production, feed intake, somatic cell count, methane emissions per kg ecm and replacement rate changed. When calf mortality was changed, it altered milk yield, somatic cell count, lifetime production and replacement rate.

5. Results

The calculated marginal economic values are presented in table 3. They express the economic value of a trait per cow per year when other traits remain constant. The values presented in table 3 are average values on traits milk yield, mastitis, feed efficiency and body weight. On traits conception rate cows, conception rate heifers, cow mortality, calf mortality, claw and feet diseases and other culling the scenario more desired by NTM is chosen. For milk yield, conception rate and feed efficiency increase in the parameter improved the profitability in all herds. For mastitis, cow mortality, calf mortality, claw and feet diseases, body weight and other culling a decrease in the parameter gave an economically positive result for all herds.

Table 3. Marginal economic values

Trait	A	B	C	D	E(organic)	F	G(organic)
ECM (e/kg)	0,27	0,32	0,29	0,33	0,41	0,35	0,42
Mastitis (e/%)	1,05	1,35	1,05	1,15	2,30	0,90	2,15
Conception rate cows (e/%)	3,20	3,20	1,60	2,00	4,60	9,20	0,40
Conception rate heifers (e/conception rate point)	0,80	0,80	0,80	1,40	0,40	1,40	0,60
Cow mortality (e/%)	16,67	18,70	13,64	13,82	33,21	18,39	20,00
Calf mortality (e/%)	0,89	4,60	1,52	2,40	12,20	5,20	2,40
Claw and feet diseases (e/%)	1,90	1,40	1,50	1,60	3,10	2,20	2,4
Feed efficiency (e/kg of feed)	0,19	0,25	0,14	0,20	0,32	0,20	0,32

Body weight (e/kg)	0,13	0,18	0,07	0,22	0,02 / 0,10	0,18	0,15
Other culling (e/%)	4,63	7,22	5,20	3,72	8,30	21,35	6,89

Standardized economic values were calculated from marginal economic values to compare the economic importance of different traits as in Hietala et al. (2014).

Standardized economic values (evs) were calculated as follows:

$$evs = ev \times s$$

where ev is the economic value for trait and s is the genetic standard deviation of that particular trait. All calculated standardized economic values and their genetic standard deviations (Slagboom et al. 2018, Sorensen et al. 2018, Muuttoranta et al. 2015, Nielsen 2006) are presented in table 4.

Table 4. Standardized economic values and their standard deviations of different breeding goal traits

Farm ID / Trait	A	B	C	D	E	F	G	gen. s.d.
ECM	17,3	20,7	18,7	21,2	26,5	22,5	26,7	63,9
Mastitis %	0,08	0,11	0,08	0,09	0,18	0,07	0,17	0,08
Conception rate cows %	2,16	1,96	0,88	0,69	4,51	6,86	0,88	0,49
Conception rate heifers %	0,86	0,96	0,38	0,19	0,19	0,67	0,19	0,48
Cow mortality %	0,83	0,93	0,68	0,69	1,66	0,92	1,00	0,05
Calf mortality %	0,06	0,32	0,11	0,17	0,85	0,36	0,17	0,07
Claw and feet diseases %	0,06	0,04	0,05	0,05	0,09	0,07	0,07	0,03
Feed efficiency	0,22	0,29	0,17	0,24	0,39	0,24	0,38	1,2
Body weight kg	4,41	6,10	2,37	7,46	0,68/3,39	6,10	5,09	33,9
Other culling %	0,23	0,36	0,26	0,19	0,42	1,07	0,34	0,05

Relative economic values of different breeding goal traits were calculated from standardized economic values as in Hietala et al. (2014), but not splitting to direct and maternal components.

$$evr = 100\ x\ \frac{|evs_{lj}|}{\sum_l \sum_j |evs_{lj}|}$$

Here *evs* is the relative economic value for a trait lj and evs_{lj} is the standardized economic value for a trait lj. All relative economic values calculated in this study are presented in table 5.

Table 5. Relative economic values in percentage of the sum of standardized economic values over all traits

Farm ID / Trait	A	B	C	D	E	F	G
ECM kg	66,0 %	65,2 %	79,0 %	68,5 %	74,6 %	57,9 %	76,3 %
Mastitis	0,3 %	0,3 %	0,3 %	0,3 %	0,5 %	0,2 %	0,5 %
Conception rate cows	8,2 %	6,2 %	3,7 %	2,2 %	12,7 %	17,7 %	2,5 %
Conception rate heifers	3,3 %	3,0 %	1,6 %	0,6 %	0,5 %	1,7 %	0,5 %
Cow mortality	3,2 %	2,9 %	2,9 %	2,2 %	4,7 %	2,4 %	2,9 %
Calf mortality	0,2 %	1,0 %	0,5 %	0,5 %	2,4 %	0,9 %	0,5 %
Claw and feet diseases	0,2 %	0,1 %	0,2 %	0,2 %	0,3 %	0,2 %	0,2 %
Feed efficiency	0,8 %	0,9 %	0,7 %	0,8 %	1,1 %	0,6 %	1,1 %
Body weight	16,8 %	19,2 %	10,0 %	24,1 %	2,1 %	15,7 %	14,5 %
Other culling	0,9 %	1,1 %	1,1 %	0,6 %	1,2 %	2,8 %	1,0 %

Relative economic values in table 5 show that ECM yield has the highest economic value on all farms, like expected. Body weight and conception rate of cows also stand out from the table on most farms. Economic values of cow mortality and conception rate of heifers are also relatively higher than economic values of health traits.

6. Discussion

Results differ between farms due to genetic and management differences. Results between farms are described in figures 1-4, which show the standardized economic values of different traits for each farm. Traits are divided into four groups: ECM, fertility traits, health related traits and feed efficiency and body weight. Figures are composed from results presented in table 3.

Economic values for ECM are in line between the farms located in the same subsidy area (figure 1, table 1). Farms A and C, which are located in southern Finland with no coupled subsidy based on milk production have lower economic values than farms B, D, and F, which are located in northern Finland with a subsidy per milk liter. Organic farms E and G, which are in the same subsidy area, have almost equal economic values for ECM yield. The difference in economic value between conventional and organic farms is due to a higher price on organic milk.

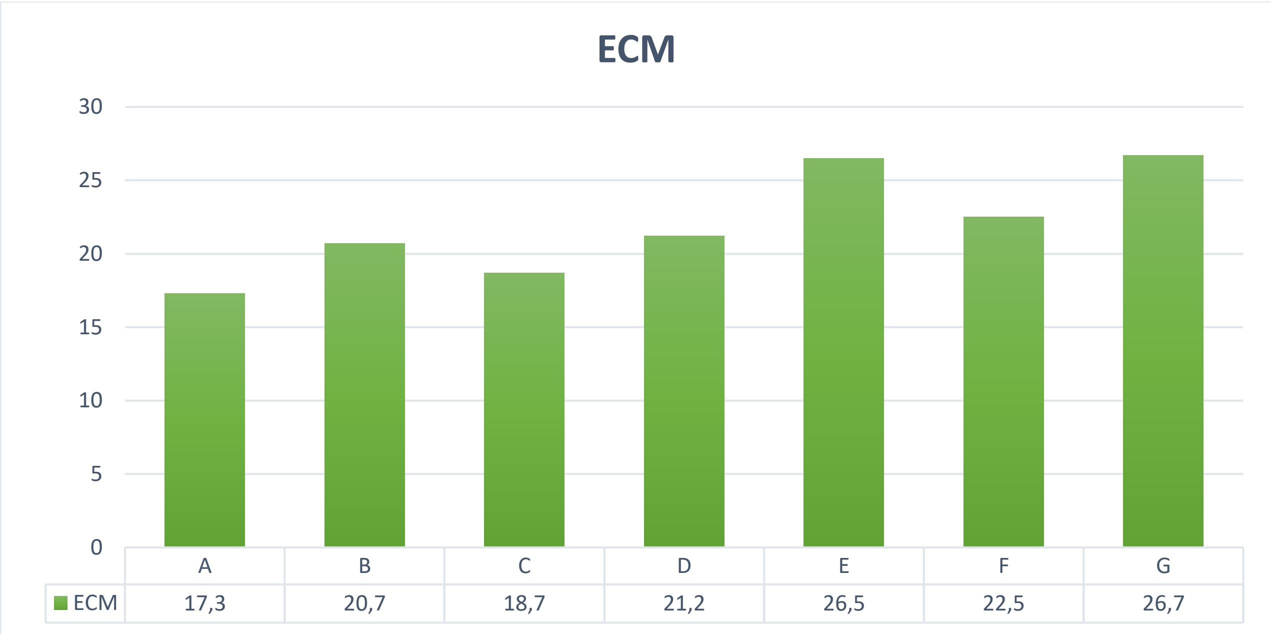


Figure 1. Comparison of standardized economic value of ECM between farms

As mentioned earlier, breeding goals can be divided into two groups since they either bring more revenues or reduce costs (Bo, 2009). That explains the economic values of milk yield and feed efficiency. Only variable costs were considered in this study. Energy corrected milk has indisputably the greatest economic value among the individual traits, which supports our assumption of milk being economically the most important trait. Farmers get their revenues mainly from milk, which makes the economic value of milk highly reliant from markets. A change in markets, due to different pricing systems or subsidy strategies could have an impact on economic value of milk. Slagboom et al. (2016) presented in their study, that organic farmers often put more weight on production traits in selection than conventional, since milk yield per cow is usually lower for organic farms compared to conventional. They also suggest that higher price per product is one main reason for farmers' preference on production traits. In this study the greater economic value on organic farms compared to conventional farms can be explained with a higher price for the product, since the annual milk production per cow of organic farms in this study did not differ significantly from conventional farms.

Economic value of cow conception rate is relatively high on farms F and E. This is due to a short insemination interval and therefore a high culling rate of cows that do not conceive during that period. For farms E and G the economic value of heifer conception rate is lower, since their heifers are naturally bred using a farm bull, which leads to a better heat observation rate and conception rate. These farms did not have exact data of conception rate of heifers, which might also have an impact on these results. Differences between farms can be seen in figure 2, where standardized economic values of fertility traits are presented. Fertility traits include in figure 2 conception rate of cows (ConcCows) and conception rate of heifers (ConcHeif). Conception rate is highly affected by management factors, such as heat observation rate and timing of inseminating as well as feeding and social hierarchy in the herd, which both reflect in estrous behavior and thus conception rate (Badinga et al. 1985). In this study the heat observation rate was kept constant on the current performance level observed on the farm for each of the simulated scenarios.

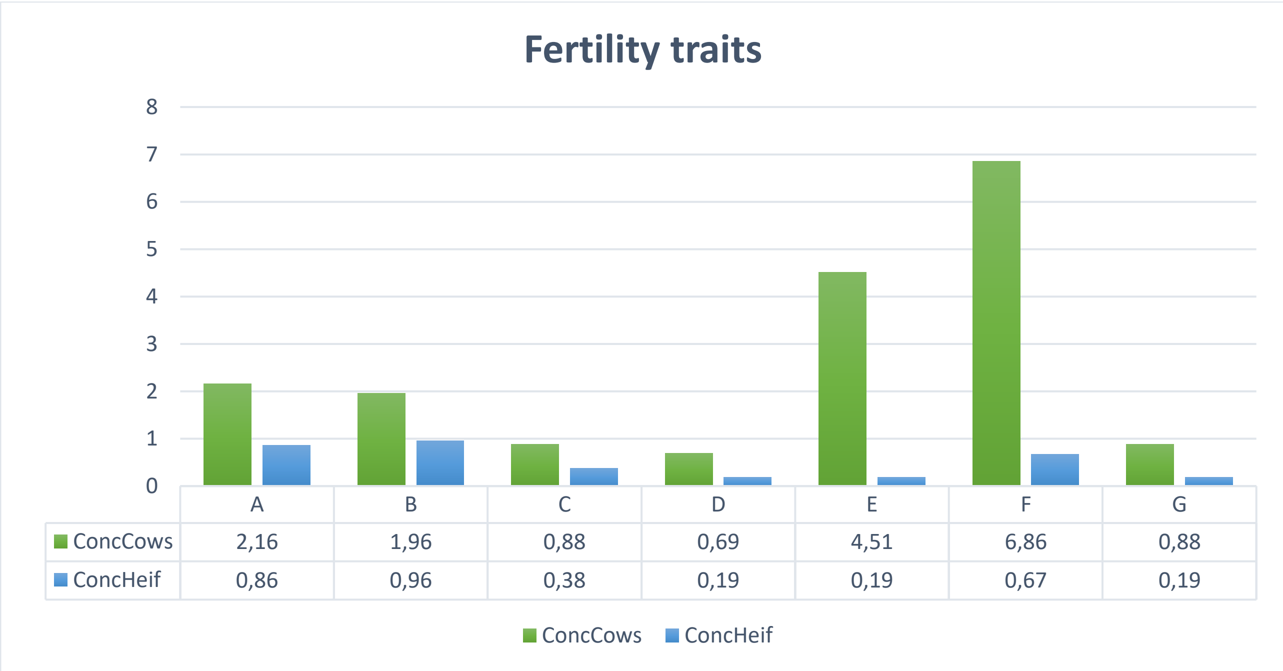
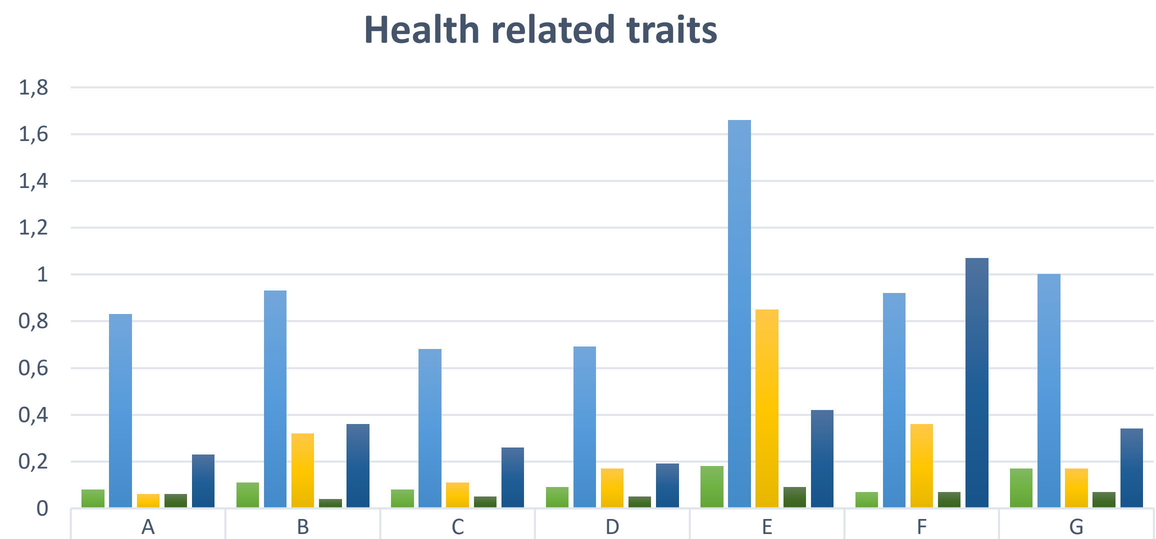


Figure 2. Comparison of standardized economic values of fertility traits between farms

Economic value of conception rate consists of many aspects. Conceiving is required in order to enter the next lactation, which lengthens production age of cows and improves lifetime production. According to Palmio et al. (2016) the yearly production of a dairy cow increases every lactation, until the 5th calving. When a cow conceives within the insemination period, the number of cows culled, need of replacement heifers and the number of low-yielding days per lactation decrease (Wall et al. 2010). Conception rate has a big effect on calving interval, which affects the milk yield per cow per year, and therefore has a big economic value (Kargo et al. 2014). Lower conception rate of cows results in more culled cows per year, which affects longevity and requires more replacement heifers. These are important factors in reducing costs, improving profitability and reducing environmental impacts of dairy production. If conception rate of heifers is low, the heifers enter their first lactation later than at the age of 24 months, which has a negative impact on milk yield of the first lactation. According to Fodor et al. 2020, after the age 25.99 months at first calving, milk yield decreases and risk of culling within the first 50 days of first lactation increases along with increased calving age.



	A	B	C	D	E	F	G
Mastitis	0,08	0,11	0,08	0,09	0,18	0,07	0,17
CowMort	0,83	0,93	0,68	0,69	1,66	0,92	1
CalfMort	0,06	0,32	0,11	0,17	0,85	0,36	0,17
ClawFeet	0,06	0,04	0,05	0,05	0,09	0,07	0,07
OtherCull	0,23	0,36	0,26	0,19	0,42	1,07	0,34

Mastitis CowMort CalfMort ClawFeet OtherCull

Figure 3. Comparison of standardized economic values of health-related traits between farms

Figure 3 shows economic values of health-related traits which here include mastitis, cow mortality (CowMort), calf mortality (CalfMort), claw and feet diseases (ClawFeet) and other culling (OtherCull). From figure 3 and table 3 we can tell that cow mortality has the highest marginal economic value in all farms after ECM. This is mostly due to a high price of a milking cow, if cows need to be purchased to maintain a planned number of cow years. Organic farms stand out from the table 3, since the price of a milking cow is higher than on conventional farms.

Variation of economic value of mastitis exists between farms, although the differences between farms of the same production type are not as big as between conventional and organic farms. Mastitis is one of the main reasons for early culling in Finland (Nokka, 2019). Mastitis causes not only veterinary costs but also costs in milk disposal, reduced production, involuntary culling and in worst cases increased mortality of animals (Heikkilä et al. 2008).

The farms who entered the study had only non-infectious claw lesions, such as white line and sole ulcer. Lameness from other feet and legs-related diseases than claw lesions was also added in the trait claw and feet. Lameness altogether can cause production reduction (Rajala-Schultz et al. 1999), infertility (Hernandez et al. 2001) and involuntary culling (Sogstad et al. 2007).

Health traits do not affect only the economics of the farm but are also strongly connected with animal welfare. Improving mastitis and lameness have multiple non-economic values, such as reduced discomfort and pain (Lawrence et al. 2004). Consumers are all the time more eager to know how their food is produced and require better animal welfare for production animals (Lehtonen 2020). Breeding for better welfare of animals is not a common practice in Finland, but a change in markets, for example a higher milk price for better welfare or higher cost in veterinary treatments or a more strict use of antibiotics could change the value of breeding for health and therefore better animal welfare.

On farm level, cow mortality is a part of longevity. It is normally affected by diseases, accidents and unexplained mortality, but in this study double counting was considered and influences of different diseases were removed. Improving longevity reduces costs of replacements and improves life-time milk yield of cows. Higher life-time milk yield results also in smaller environmental impact of one liter of milk, since the number of non-milking days is smaller compared to milking days (Weiske et al. 2006). Longevity is affected also by many other traits than mortality. It can be described as length of farm life, that consists of production and fertility traits, or functional longevity, that consists of health and conformation -related traits (Clasen et al. 2017, Punsmann & Distl 2017).

Finnish dairy cows are young. According to ProAgria, in 2019 33 percent of dairy cows were on their first lactation. The number of cows on their fifth lactation, which was recorded as the highest yielding lactation, was only 6 percent of Finnish dairy cows (Nokka 2019). This shows that cows are either culled or die too early in order to give their full production potential. Nokka (2019) shows in her report that the most common reasons for culling in 2018 were fertility, udder health and production or breeding value. These traits cover approximately half of all reasons for culling for both first and later parity cows. Therefore, traits affecting longevity: mortality, conception rate cows and conception rate heifers as well as other culling cover a greater percentage in table 5. Improving longevity of cows would also show an improvement in breeding values, since cows with poorer performance could be culled voluntarily and the intensity of selection could be higher due to smaller replacement rate (Miglior et al. 2017). According to Heikkilä et al. (2008) replacing a dairy cow is profitable only when the cow being replaced is the oldest and poorest in production cow of the herd. Treating a health issue is more profitable than replacing a dairy cow always, when the production of the cow is average or higher (Heikkilä et al. 2008).

Economic value of calf mortality after birth differ between farms for two reasons. Farm B and D rear all their bull calves until slaughter and therefore have a higher marginal economic value for that trait. Farm E has a strategy, where cows are culled at young age, since the farmer prefers young cows. This strategy, where all born heifer calves are needed as replacement heifers, makes the marginal economic value of calf mortality relatively higher than on other farms. Farm G stands out from the results being an organic farm which grows their bull calves until slaughter, but still has a lower economic value than other farms with the same strategy. On economic values of claw and feet diseases the farms E, F and G have a greater value, mostly due to being organic (E and G) or having a maximal use of beef bull inseminations, that is sensitive to unexpected changes (F).

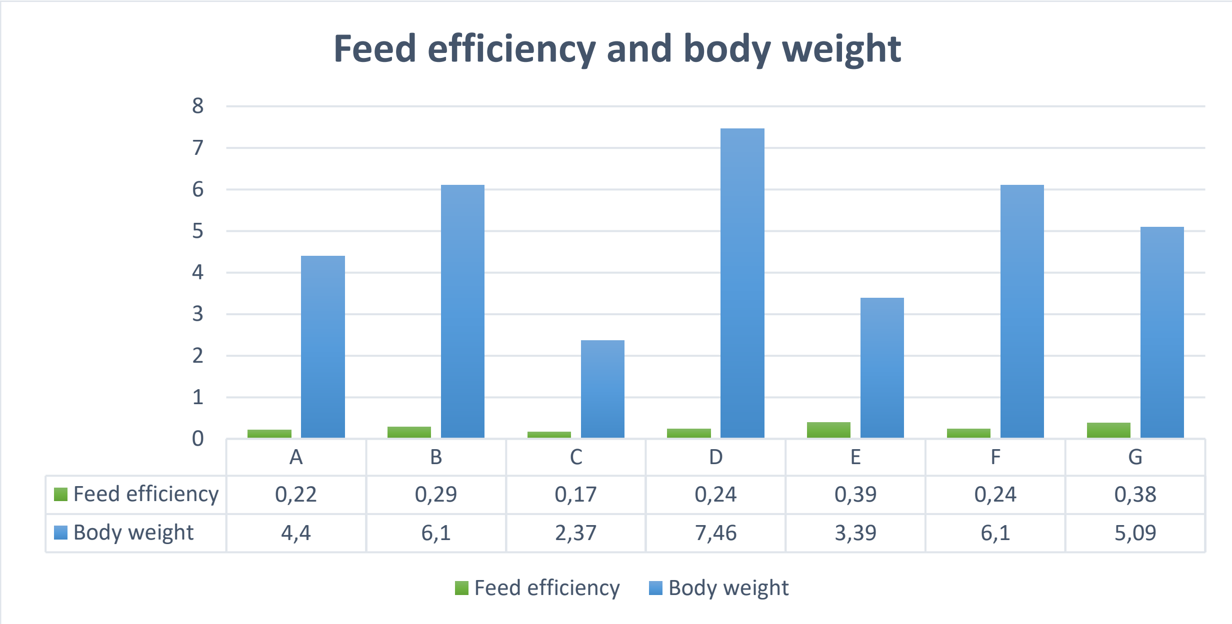


Figure 4. Comparison of standardized economic values of feed efficiency and body weight between farms

The cost of feed is the highest cost in Finnish dairy production (Hietala et al. 2014). Economic value of feed efficiency changed between farms due to different prices of roughage. In figure 4 standardized economic values of feed efficiency and body weight are presented. Although farm specific prices of roughage were not available, farms A and C have a lower price of roughage since they are located in southern Finland, where the growing season is longer, and yields are greater. Organic farms E and G have a higher price for roughage and feed. Marketing strategies have a relatively high impact on economic value of feed efficiency, since all economic values are highly dependent of production systems and markets in the future (Gibson and Dekkers, 2009). The importance of feed efficiency might increase in the future, since its environmental impacts are continuously discussed due to the need of mitigating greenhouse gas emissions from dairy production (Hietala et al. 2014). Also, a change in costs of feed or subsidy strategies would show a change in economic values of feed efficiency. Although feed efficiency can also be improved through nutrition or management, genetic selection would bring a more permanent improvement, with greater advantages and more cost-efficient results than relying only on nutrition or management (Richardson et al. 2019).

In this study the economic value of body weight was found to be relatively high, being even 24,1 percent of the sum of standardized economic weights over all traits. A similar result was found in Hietala et al (2014) study, where mature weight of cows accounted for 6 to 11 percent of the sum of the absolute values of the standardized economic weights over all traits. According to Koenen et al. (2000), the economic value of dairy cows' live weight has ranged between -0.29 and -0.17 and depended highly on beef prices and feed costs. High relative economic value over all traits might be explained with the model. Only farms C and E, whose percentages are also the lowest, had cows whose average body weight was close to the SimHerd assumption. On farms A, F and G cows' average body weight was slightly greater (100-200kg) than the assumption and farms B and D had significantly heavier cows (400kg) than the assumption in SimHerd.

Animals with higher body weight have also greater energy requirements for maintenance (Owens et al. 1993, Capper & Cady 2012). Smaller heifers are more desirable as replacement heifers, since they reach their puberty earlier in life than heifers with greater mature weight (Owens et al. 1993). In Owens et al. (1993) meta-analysis from years 1988-1998 they found out that in most of those studies, marginal feed costs were higher than marginal beef revenues when live weight was increased. This is mostly due to increased maintenance energy requirements and therefore increased costs. VanRaden et al. (2002) suggested that higher mature weight of cows also results in greater costs of housing. In his study he proposed that reducing mature weight of cows might result in better profits, if reduced costs from feed and housing are greater than income from beef.

On trait body weight all other farms' value is presented as a mean of values in increased and decreased scenarios except farm E. Farm E had such a great difference between the two scenarios that an average would not have shown the actual economic value. From table 4 one can see that farm E differed from other farms with a positive economic value on both scenarios, instead of showing a negative economic value for body weight increase. On calculating relative economic values, the greater value was chosen. In this case that is from the scenario, where body weight was decreased.

Table 6. Economic values of body weight

Farm ID	Increasing the parameter e / kg	Decreasing the parameter e / kg
A	-0,12	0,14
B	-0,18	0,18
C	-0,08	0,06
D	-0,24	0,2
E	0,02	0,1
F	-0,18	0,18
G	-0,16	0,14

This difference could be explained with a higher price for organic meat, but since the same positive change does not show on farm G, the price of a culled cow does not explain this fully. Farm E has smaller cows than farm G, since the average live weights on farm E and G are 680 kg and 728 kg, respectively. The reason, why also an increase in cows' body weight gives a positive economic value for farm E but not the others, might be the current level of body weight. To improve the economic ratio of milk production, feed efficiency and price per culled cow, the current average of cows' body weight could be increased. The economic value of an increased kilo of body weight is relatively small and would not show or matter in real life. The economic value per a decreased body weight kg (0,1) is higher than the economic value per increased body weight kg (0,02).

Differences of economic values of different breeding goal traits in this study can partially be explained with different management of the farms who entered the study. Standardized economic values and relative economic values presented as percentage are not equal but at the same magnitude across all farms, except a few individuals (tables 4 and 6). The results might be different, if the calculations were more accurate. In this study, the problem was that the farms did not have exact data on for example the cost of roughage or the amount of work hours they needed per different tasks. That forced the author to do approximations and standardizations, which might reflect in the results. According to the results of this study, there would be no need for farm specific total merit index. During the interviews of farmers for this study the authors found out that breeding goals differed between farms. Among these seven farms the farmers preferred either NTM, production, fertility or conformation traits, and some had “easy cows” as their breeding goal. These differences in preferred breeding goals suggest a need for multiple TMIs based on farmers’ preferences and this should be researched further.

6.2 Results chosen for the analysis

During the simulations, unexpected results occurred, especially on traits with a change in management. SimHerd assumes that the stage of management remains constant for the simulated 6 to 10 years. This caused unexpected results on simulations, where a change in parameter caused a change in number of cows in different categories. Changes in cow categories took place when parameters claw and leg problems, cow mortality, calf mortality and other culling were changed. The change was biggest on farms B and F, where the standard situation was in balance but not robust change, due to high use of beef bull semen, and lac of extra heifers. Same situation occurred on farm E, where voluntary culling is kept on high level. These farms need all their dairy heifers as replacement heifers. Since the program assumes that management and other parameters stay constant, it leads to a situation where farms need to buy heifers in order to keep a certain number of cows. That situation is not realistic, since we can suppose that farmers would change their management strategies on beef semen use or voluntary culling in situations, where the total number of cows in herd might decrease below their normal number of cows. The situation where a farm needs to buy many heifers without making any changes in management would eventually lead to an economic disaster, as could be seen from SimHerd reports. Economic values of these simulated cases were not realistic and were not considered in this study. For traits cow mortality, calf mortality, hoof and leg diseases and other culling the scenario which is parallel to NTM was chosen for the analysis. This was in all these cases the situation where risk was decreased.

6.3 Results between production types

One of the objectives of this study was to study if the economic values of breeding goal traits differ between different production types. Comparisons of average standardized economic values between organic and conventional farms are presented in figures 5 and 6. These results are only directional and should be treated with caution, since this study had only two organic farms. With only two economic values for each trait the average is easily affected by variation between farms. From figure 5 we can tell that the economic values of health traits, conception rate of cows, calf mortality and feed efficiency are greater in organic production compared to conventional. Correspondingly the economic values of heifer conception rate and other culling are greater in conventional production. In figure 6 economic values of ECM and body weight are presented. Economic value of ECM is greater for organic production, and economic value of body weight is greater for conventional production.

Higher economic values of health traits, here mastitis and claw and feet diseases can be explained with more strict use of antibiotics and longer withdrawal time of milk after antibiotic treatment (ProLuomu). Economic values of conception rate of cows, cow mortality and calf mortality are greater due to higher price of a replacement dairy cow or heifer, in those cases where it needs to be purchased from another farm. Feed efficiency is explained with a higher price of feed for organic farms. The difference of economic values of ECM can be explained with only higher price for organic milk.

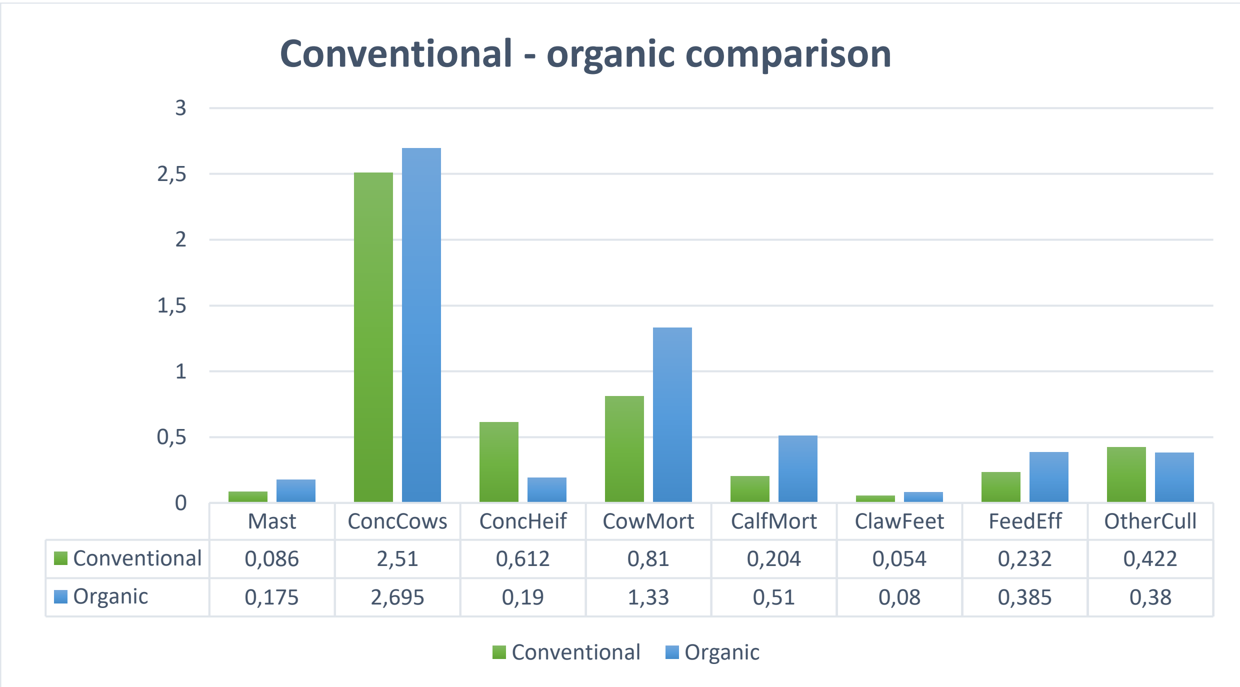


Figure 5. Comparison of average standardized economic values between conventional and organic farms

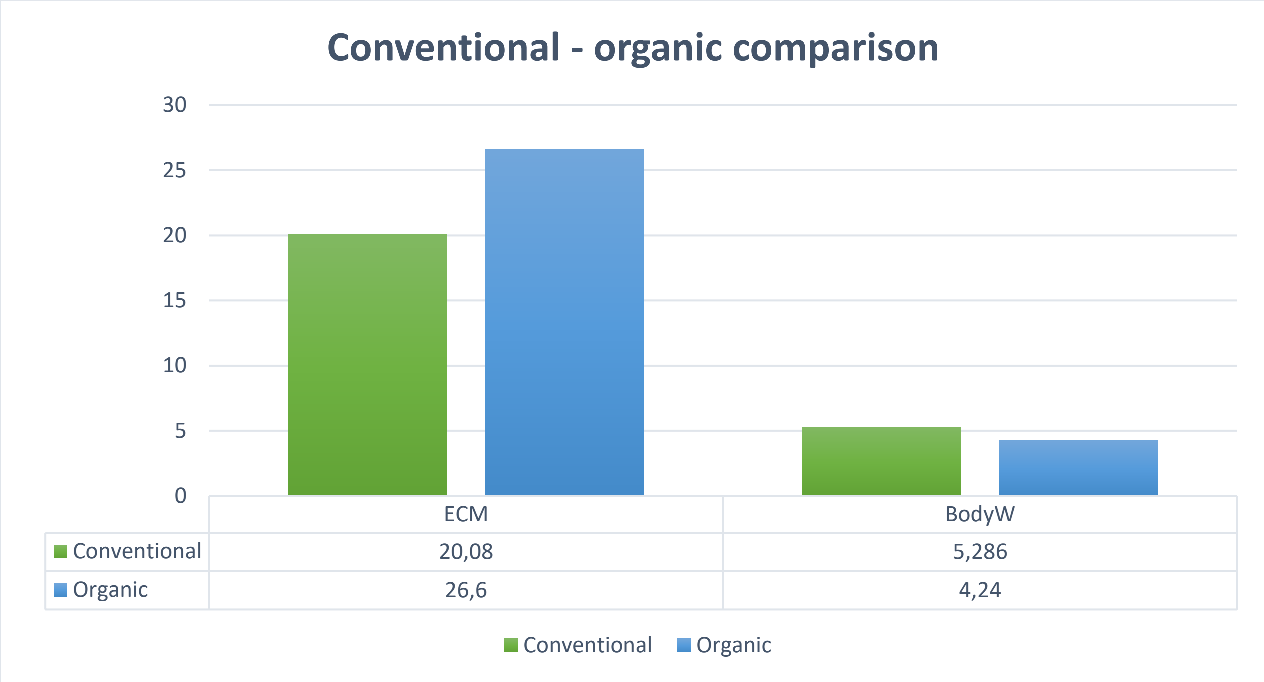


Figure 6. Comparison of average standardized economic values between conventional and organic farms

Nordic Total Merit (NTM) is used in Finland as a joint breeding goal (Kargo et al. 2014). NTM is based on economic values, except a few changes proposed by the breed organizations (Soerensen et al. 2018). One of the changes was that NTM is based on conventional production. Therefore, a comparison between the weights of NTM and results of this study for organic production was made. In table 7 final NTM weight relative to yield index for each NTM sub-index (Soerensen et al. 2018) are presented. Since the weights of NTM are not economic weights, only the importance of traits was taken under consideration. In table 8 the average values of relative economic values in percentage of the sum of standardized economic values over all traits are presented for both organic and conventional production.

Table 7. Relative final NTM weights for each NTM sub-index for HOL

NTM sub-index HOL	
Yield	1,00
Growth	0,09
Fertility	0,40
Birth, direct	0,16
Calving, maternal	0,16
Udder health	0,33
General health	0,15
Frame	0,00
Feet & legs conformation	0,05
Udder conformation	0,20
Milkability	0,10
Temperament	0,04
Longevity	0,07
Claw health	0,11
Young stock survival	0,14

Table 8. Average percentages of the sum of standardized economic values over all traits

Trait	conventional	organic
ECM	67,3 %	75,4 %
Mast	0,3 %	0,5 %
ConcCows	7,6 %	7,6 %
ConcHeif	2,0 %	0,5 %
CowMort	2,7 %	3,8 %
CalfMort	0,6 %	1,4 %
ClawFeet	0,2 %	0,2 %
FeedEff	0,8 %	1,1 %
BodyW	17,2 %	8,3 %
OtherCull	1,3 %	1,1 %

For organic production according to table 8 traits ranked after their importance are ECM yield, body weight, conception rate of cows, cow mortality, calf mortality, other culling, feed efficiency, conception rate of heifers, mastitis and claw and feet diseases. The values presented in table 7 do not cover all traits as in this study, but from there we can tell that the most important traits in NTM for 32olstein are yield, fertility, udder health, udder conformation, birth, calving, general health, young stock survival and claw health. For conventional production in this study the ranking is ECM yield, body weight, conception rate of cows, cow mortality, conception rate of heifers, other culling, feed efficiency, calf mortality, mastitis and claw and feet diseases.

Average percentages of the sum of standardized economic values over all traits differ between organic and conventional productions (figures 7 and 8). This result suggests that a separate total merit index for organic production might be justifiable. Different TMI for organic production needs to be researched more, since the economic values in this study were sensitive for differences in management, since only two organic farms entered the study.

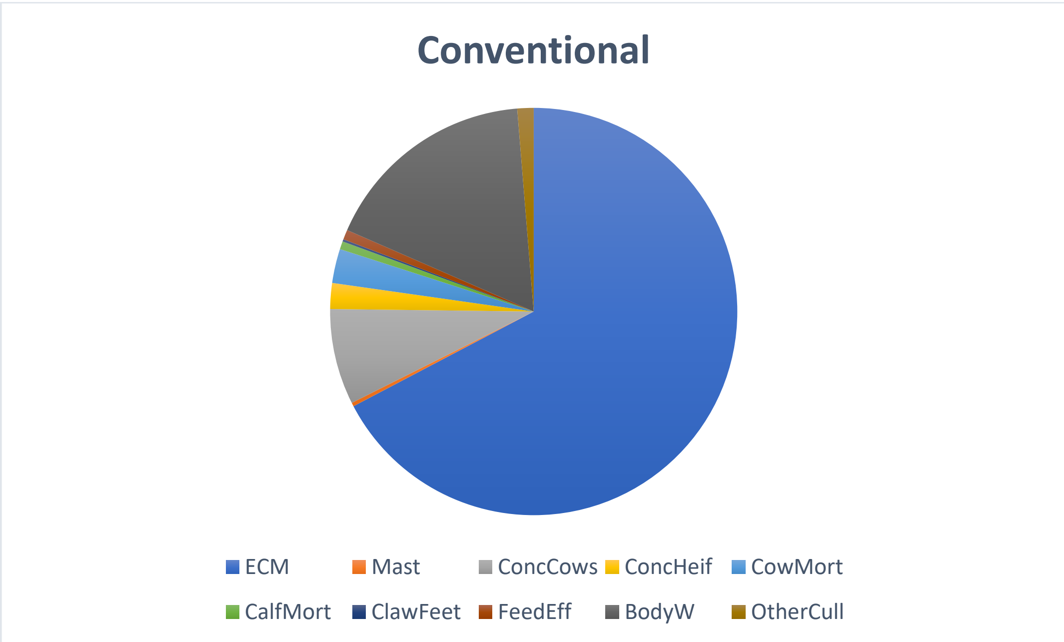


Figure 7. Average percentages of the sum of standardized economic values of conventional production

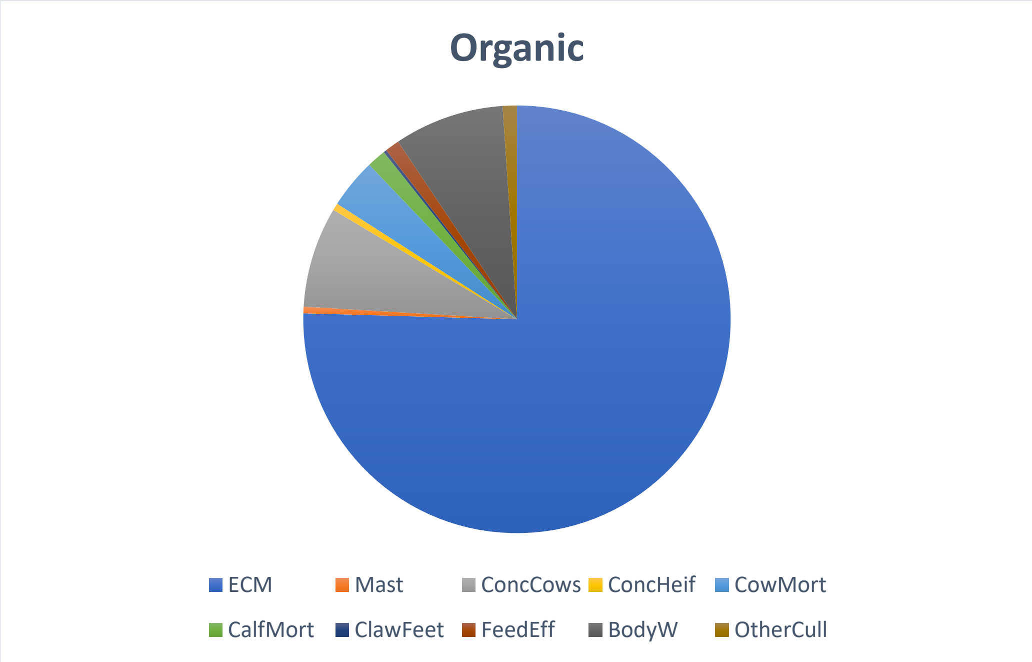


Figure 8. Average percentages of the sum of standardized economic values or organic production

7. Conclusions

As the results of this study show, farm specific economic values depend on prices, herd size and overall management. The current level of each trait has an impact on farmer's preferences on breeding goals as well as the interrelationships of economic values between traits.

Longevity as a breeding goal trait is a sum of multiple traits affecting the length of productive life, for example fertility, milk production, health traits and conformation. With improved longevity the cows have more productive years, which means greater lifetime milk yield, less replacement costs and smaller environmental impact. Although milk or ECM yield is considered as economically the most important trait with the highest economic value also in this study, more emphasis should be targeted on traits that affect longevity, especially health and fertility, since they are the most common reasons for early culling in Finland. In this study the results of simulations of trait "other culling" gave an unrealistic result for almost all of the farms, showing a highly negative economic value for increase in the parameter. This is one indicator for economic importance of longevity.

Economic values are highly dependent of production systems and markets in the future. A change in the markets would show a change also in economic values. Dairy production is now strongly affected by the price of milk, since it brings the biggest revenues to the farm. If the price of meat or bull and beef-crossed calves increased, also the economic value of body weight or calf mortality would change. Environmental factors and animal welfare issues are constantly discussed in Finnish media. New legislation or price change of feed production would have an impact on economics of dairy production and might turn the emphasis of economic values more towards feed efficiency.

According to the results of this study there ought to be no need for farm specific TMI. In this study the biggest differences in economic values between farms can be explained with management differences between farms instead of differences in genetics. Results of this study also show that Nordic Total Merit Index (NTM) has similar weighting system for breeding goal traits as the economic importance among traits in this study. That tells us that the NTM corresponds to the farm specific economic values of conventional farms. Organic farms' economic values differed of conventional farms' in this study. That suggests that a production type specific total merit index would need a further research. Instead the interviews done for collecting the phenotypic data for this study showed that different farms have different breeding goals. This points out the question, should more than one TMI be created, according to heterogeneity of farmers' preferred breeding goals. This along with the TMI for organic production needs further research.

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Attachments

Attachment 1: Phenotypic data collected from farms

Information	Unit
Number of cows	Average in 2018
Milk production per year ECM	ECM kg per year
Milk yield for 1st parity, during pfc	
Milk yield for 2+ parity, during pfc	
Somatic cell count	Average in year 2018
Calvings	Number of calvings per year
First parity calvings	Number of first parity calvings per year
Stillbirth	Number of stillbirths per year
Calf mortality	%
Cow mortality	%
Milk fever	Cases per year
Dystocia	Cases per year
Retained Placenta	Cases per year
Metritis	Cases per year
Displaced abomesum	Cases per year
Ketosis	Cases per year
Mastitis	Cases treated with antibiotics, pain killers or with differences in milk per year
Digital Dermatitis	Cases per year
Infective hoof diseaces	Cases per year
Claw and leg problems	Cases per year
Calving interval	Days
Heat observation rate	% of inseminations made during 18 to 24d
Start inseminations after calving	Breeder’s choice
Conception rate	1 / inseminations per calving
Replacement rate	%
Age at first calving	Months
Use of beef semen	%
Use of sexxed semen	%
Price of milk	e/liter
Price of a cull cow	e/kg
Price of a preagnant heifer	e/heifer
Strategy for selling heifers	Breeder’s choice (yes, sometimes, no)

Strategy for artifical insemination	AI or the breeder themselves
Growing/Selling bull calves	Breeder’s choice (sold/fattened on farm)
Salary	e/h
Cows go to pasture	yes / no